REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE July 9, 1999	3. REPORT TYPE AND DATES COVERED Final

4. TITLE AND SUBTITLE
Partial Support for the Laser Diagnostics for Combustion Gordon Research Conference

5. FUNDING NUMBERS
DAAD19-99-1-0231

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Gordon Research Conferences
PO Box 984
West Kingston, RI 02892-0984

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U. S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
ARO 39802.1-PH-CF

11. SUPPLEMENTARY NOTES
The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.

12 a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12 b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The tenth Gordon Research Conference on Laser Diagnostics for Combustion was partially supported by this ARO Grant. An extremely successful meeting was held at Il Ciocco in Barga Italy,June 20-25, 1999. In addition to the 22 invited oral presentationas, more than 110 contributed posters were presented in four sessions. The meeting was oversubscribed; attendance was limited to 140 participants, and more than 175 applications were received. The Geographical distribution of the attendees was 45% from Europe, 45% from the USA, and 10% representing Russia, Israel, Korea, Japan, and Australia. The attendees also represented a wide range of professional affiliations. The academic community provided 62% of the attendees; of these 56% were faculty and 44% were graduate students and post-doctoral researchers. The remaining 44% of the attendees were nearly equally divided between government research laboratories and industry. Of the non-academic participants 20%(9 individuals) were program managers or research directors and 80% were active research scientists. Fifty-six of the 140 participants received partial support of their meeting and/or travel expenses. This included 23 speakers and discussion leaders, 25 graduate students and post-doctoral researchers, and 8 other special cases.(small college faculty, third world and eastern block participants).

14. SUBJECT TERMS
Laser Diagnostics
Combustion

15. NUMBER OF PAGES
24

16. PRICE CODE

17. SECURITY CLASSIFICATION OR REPORT	18. SECURITY CLASSIFICATION ON THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	**UNCLASSIFIED**	**UNCLASSIFIED**	**UL**

Final Report

1999 Gordon Research Conference on Laser Diagnostics in Combustion

Il Ciocco Conference Center, Barga, Italy
June 20-25, 1999

July 9, 1999

Submitted by

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CONTENTS

1999 GORDON RESEARCH CONFERENCE ON LASER DIAGNOSTICS IN COMBUSTION

INTRODUCTION

Combustion is the major source of energy for many purposes, including transportation, and the generation of heat and electricity. For the effective use of resources and for the preservation of a clean environment, the combined action of several disciplines is required with the aim of designing efficient combustion strategies. Non-invasive diagnostics with the aid of lasers is meanwhile considered the most important tool for the experimental study of combustion processes and for the validation of numerical combustion models. Laser diagnostics permits a direct inspection of the combustion process and hence a test of the present level of understanding of combustion, and it serves as an instrument for the control and optimization of combustion systems. This meeting is the 10th Gordon Research Conference on Laser Diagnostics on combustion. Each of these meetings as been a multi-disciplinary interaction of physicists, chemists, and engineers. The identification of new frontiers for laser-based measurements, development of new techniques and instrumentation, and the validation of specific laser methods under realistic combustion conditions, provide a focus for this meeting.

MOTIVATION AND SCOPE OF THE CONFERENCE

Combustion systems constitute a harsh, high-temperature environment, and they are often characterized by extremely complex chemistry, a time-varying turbulent flow field, and, in addition, high pressure or two-phase flows. The characterization and understanding of these complicated practical environments requires correlated measurements of several variables including temperature, concentrations of major species or reactive intermediates, and flow velocities. , These measurements, as well as temporal and spatial fluctuations of these quantities, must be made without perturbing the process. Many different laser-based techniques have been and continue to be at the focus of investigations to meet these demands, including Raman and Rayleigh scattering, non-linear Raman spectroscopy, laser-induced fluorescence, multi-photon and pump-probe approaches, four-wave mixing and holographic grating techniques, and advanced laser absorption schemes. Their design and application and the interpretation of the obtained information requires a thorough fundamental knowledge of laser physics, of spectroscopy, and of combustion chemistry.

The 1999 Gordon Conference has brought leaders at the forefront of research on laser-based diagnostics from the communities of physics, chemistry and engineering together to stimulate scientific exchange and cooperation. In retrospective, compared with the first application of laser techniques to combustion studies about two decades ago, the field has matured in several respects - more techniques have been proposed, better concepts have been devised, more sophisticated tools are available, and more ambitious questions have been addressed. This is illustrated in a few examples. Some years ago, qualitative detection of important reactive species was regarded as desirable – now, we are seeing an increasing number of accurate quantitative concentration measurements. Many techniques now allow measurement in the presence of particles and surfaces and under realistic operation conditions. One-, two-, and three-dimensional approaches are readily available. Also, multi-species and multi-quantity concepts, often combining several laser techniques, are emerging. New lasers are available with faster pulses, higher repetition rates,

better beam qualities, extended wavelength regimes, and higher tunability. Similar advances in light detectors and electronics parallel these advances in laser performance. With these exciting possibilities, the field of laser diagnostics for combustion research is vibrant and – more than ever – under rapid development, meeting the increasingly pressing needs in combustion science and the related environmental considerations.

After some 20 years of combustion diagnostics, the question is permitted whether a need still exists for a development of techniques and whether laser diagnostics itself should still be a subject of investigation. It may rather appear warranted to apply the instruments devised some years ago and to leave it to the application engineer to study the combustion situations in question. However, the present, much advanced status of combustion diagnostics has been reached not only by "simply looking" into practical combustion systems, but also by studying seemingly unrelated questions such as collision processes, polarization properties, spectral line shapes and spectral interferences, laser photolysis, laser absorption, beam steering and beam profile deterioration. Sophisticated calibration schemes have enabled quantitative measurements, and chemical intuition has provided guidelines for the effective characterization of highly complex reaction systems. In spite of the many valuable approaches that it has generated, the field is still confronted by – just to name one example – the need for simultaneous quantitative in-situ measurement of all relevant scalar and vector quantities in a turbulent flame, including information on three-dimensional structures and their development in time.

ORGANIZATION

For the past two decades, the Gordon Research Conference on Laser Diagnostics in Combustion has provided a forum for international collaboration and cooperation to develop laser-based combustion diagnostics. The Gordon Conference in Il Ciocco, 1999, is the 10^{th} of this series and the first that has been held in Europe. Preceding meetings in New Hampshire have been very well received, and this Gordon Conference has become the communication focus for the combustion diagnostics community. This meeting provides an interdisciplinary environment including chemists who identify meaningful species to be measured and combustion pathways of relevance, physicists who push the limits of laser spectroscopy and laser devices, and who conceive suitable measurement schemes, and engineers who know the combustion systems and processes. The Conference has been oversubscribed in recent years, and the high demand has continued also this year in spite of the different location and time slot. After a number of applicants of 157 in 1989, 184 in 1991, 168 in 1993, 189 in 1995 and 171 in 1997, we have received 176 applications this year and were able to accept a total of 140, slightly in excess of the recommended limit of 135. Conferees have come from 12 different countries, including Australia, Canada, France, Germany, Israel, Italy, Korea, Luxembourg, the Netherlands, Russia, Sweden, Switzerland, the United Kingdom and the US.

Following is a list of Conference Chairs and Vice Chairs since its inception:

1981 Chair: John W. Daily (UC Berkeley)
Vice Chair: David R. Crosley (SRI International)

1983 Chair: David R. Crosley (SRI International)
Vice Chair: Alan C. Eckbreth (United Technologies)

1985 Chair: Alan C. Eckbreth (United Technologies)
Vice Chair: Ronald K. Hanson (Stanford)

1987 Chair: Ronald K. Hanson (Stanford)
Vice Chair: Richard K. Chang (Yale)

1989 Chair: Richard K. Chang (Yale)
Vice Chair: Larry A. Rahn (Sandia National Laboratory)

1991 Chair: Larry A. Rahn (Sandia National Laboratory)
Vice Chair: Kermit C. Smyth (NIST)

1993 Chair: Kermit C. Smyth (NIST)
Vice Chair: Jean-Pierre Taran (ONERA, France)

1995 Chair: Jean-Pierre Taran (ONERA, France)
Vice Chair: Marshall B. Long (Yale)

1997 Chair: Marshall B. Long (Yale)
Vice Chair: Katharina Kohse-Höinghaus (Univ. Bielefeld, Germany)

1999 Chair: Katharina Kohse-Höinghaus (Univ. Bielefeld, Germany)
Vice Chair: Jay B. Jeffries (SRI International)

The conference was held in accord with GRC policy with formal sessions in the morning and evenings (see attached Program) and with a poster session of more than 25 posters each every night from Monday throughout Thursday. With a total of approx. 110 posters, including post-deadline submissions, the number of posters was a record high with almost every attendee an actively participant in the conference (see attached Poster Program).

SCIENTIFIC ASPECTS ADDRESSED AT THE CONFERENCE

The Gordon Conference format does not permit publication of any kind, including abstracts of lectures and posters. It is thus difficult to summarize important issues without violating this concept. For encouraging controversial discussion at the conference, 3 short discussion items were identified by the speakers prior to the conference and made accessible for preparation of the participants through the conference home page.

The technical sessions were grouped approximately in a row of increasing complexity of combustion problems and complemented by similar poster topics in the evenings. The conference started with an attempt to judge the status of development for different application purposes of linear and non-linear diagnostic techniques, concentrating on LIF and DFWM, one of the most important molecules to detect being NO. Practical aspects including e.g. the suitability for engine diagnostics were addressed.

An entire session was devoted to the analysis of pollutants including soot, soot precursors and trace gas species being present in the combustion chambers or the exhaust. Due to the chemically extremely complex nature of the combustion processes involved, laser-based diagnostics faces enormous challenges and needs to be complemented by other sensitive chemical analysis techniques such as advanced mass spectrometry schemes for in-situ detection. A recommendation for further development may be to not discuss laser-based and non-laser approaches in two separate communities, and attempts were made to establish links.

The Monday evening session provided complementary avenues for picosecond diagnostics, focussing either on high-energy laser sources or high repetition rates. While short-pulse combustion diagnostics has been developed since some years, the first complete session on combustion results has now acknowledged the presence of reliable laser and detection systems and measurement techniques.

Combustion chemistry regarding not only pollutant species, but also intermediates involved in the large reaction networks responsible for their generation, has attracted considerable attention in the last Combustion Symposia, e.g. addressing subjects of NO formation and reburning chemistry. A question of paramount interest for the diagnostics community, if their results are to be used to improve combustion understanding and modeling, is to identify what is useful to measure and how this may be achieved. While presentations at past Gordon Conferences have shown that quantitative radical measurements are possible, only few species of interest have actually been measured. Satisfactory agreement of one species measured at a single set of conditions with model calculations may no longer be regarded as a way to learn about combustion chemistry. The discussion has attempted to focus on meaningful measurements, regarding reburning and fire suppression as well as hydrocarbon chemistry as examples.

Tuesday evening has focussed on active combustion control with two complementary presentations on control concepts and sensor development. In this exciting field of research, avenues for future research have been illustrated, and some of the next conferences will probably see an increasing activity in this area.

The following two sessions on Wednesday were devoted completely to combustion problems of great practical interest, such as to devise measurements for combustors, gas turbines and engine environments. Two-phase and high-pressure systems, partly loaded with particulate matter, prove to be amenable to diagnostics although this research must be regarded as extremely challenging. Also, heterogeneous processes as in catalytic combustion need to be addressed, and feasible approaches are emerging. As one of the most pressing problems, turbulent combustion has been discussed. Here, the large range of length scales, the need for simultaneous diagnostics of scalar and vector quantities and the necessity to follow structures in time pose difficulties that have seen almost a generation of combustion diagnosticians at work. This topic, while having been addressed several times at past conferences, is likely to be continuing well into the next.

Diagnostics is now capable of advanced measurements, including flow diagnostics without particle seeding, and new measurement results will inspire new developments in numerical modeling.

The last conference day was devoted to identifying new questions for the community, and to introduce new approaches and instruments. As one of the bridges into adjacent fields, a link was established between the generation of pollutants and their role in atmospheric chemistry as well as between combustion emissions and diagnostic avenues for toxic emission control. Also, combustion as a chemical reactor for desired new materials was discussed. It has been made clear that laser diagnostics has important new subjects not only by studying processes inside a combustion system, but also by using this background in related fields, where much of the same know-how is needed. As potential development for more sophisticated future investigations, new laser sources and high-speed diagnostics approaches were highlighted in the final presentations. Poster sessions were most actively used in the discussion of the questions brought forward during formal sessions, and in the presentation of additional material.

FUTURE CONFERENCE

In the business session on Wednesday afternoon, June 23, the participants voted unanimously for a continuation of this Gordon Conference. It was decided, in accord with tradition, to keep the conference on biannual schedule (an unanimous vote thus was obtained for holding the next conference in 2001).

The question of the next conference location was discussed, and a broad majority of participants voted for a Rhode Island site in late June, with Connecticut as second priority. The chair of the forthcoming conference, Dr. Jay Jeffries, was asked to check conflicting meetings and to support the opinion of the community in his interactions with the GRC scheduling committee.

Prof. Marcus Aldén of the Lund Institute of Technology, Sweden, was elected as the next Vice Chair in a close ballot.

FUNDING SOURCES FOR CONFERENCE FEES AND TRAVEL

Gordon Research Conferences Special Fund		$ 17,300.00
Army Research Office		$ 8,925.00
DoE Morgantown Energy Technology Center		$ 5,000.00
NASA Ames Research Center		$ 5,000.00
NASA Langley Research Center		$ 2,500.00
National Science Foundation		$ 8,100.00
Eastern European Fund		$ 500.00
	Total	**$ 47,300.00**

EXPENDITURES FOR CONFERENCE FEES AND TRAVEL

Speakers and Discussion Leaders		
14 US		$ 18,155.21
9 Non-US		$ 9,509.79
Graduate Students and Post Docs		
12 US		$ 6,930.00
13 Non-US		$ 7,520.00
Other Conferees		
4 US		$ 2,240.00
4 Non-US		$ 2,340.00
56 persons supported	**Total**	**$** 46,695.00

MISCELLANEOUS FUNDING SOURCES AND EXPENDITURES

Industrial Support

OWIS	Euro	200.00
LaVision	Euro	300.00
Spectra Physics	DM	500.00
Spectra Physics	$	750.00
Continuum	$	500.00
	Total $	**2,000.00**

Expenditures

Refreshments at poster sessions and miscellaneous	$	1,964.00
Office expenses in Bielefeld	$	600.00

Several European participants were funded by various European agencies.

The 1999 Gordon Research Conference
on Laser Diagnostics in Combustion

Il Ciocco Cenference Center
Barga, Italy
June 20-25, 1999

Katharina Kohse-Höinghaus, Chair
Jay B. Jeffries, Vice Chair

Sunday, June 20, 1999

18.00-19.15 Dinner

19.15 Katharina Kohse-Höinghaus, chair: Welcome and introduction to the Conference

19.30-22.00 **Linear vs. non-linear diagnostics: general developments**

Discussion leader: Alan Eckbreth (United Technologies Research Center, Hartford, USA)

- Volker Sick (U Michigan, Ann Arbor, USA):
  Linear laser-based diagnostics beyond its limits for engine diagnostics?
  - Can we still learn something about internal combustion engines using laser diagnostics?
  - Does accuracy, sensitivity or selectivity limit us?
  - Can we measure the 'right' things?
- Paul Ewart (U Oxford, UK):
  Nonlinear spectroscopic techniques in the real world
  - Would a spectral simulation package for DFWM be of use to the community?
  - What species, (and therefore what spectral range) and/or combustion parameters, if any, are suitable cases for treatment by DFWM?
  - What advances in laser technology would assist application of FWM and related grating techniques?

Monday, June 21, 1999

7.30-8.30 Breakfast

8.30-12.30 **Optical vs. probe techniques: PAH and soot diagnostics**

Discussion leader: Lisa Pfefferle (U Yale, New Haven, USA)

- Jerry Seitzman (Georgia Tech, Atlanta, USA):
  Laser-induced incandescence for soot measurements in combustion and exhaust flows
  - Has LII really been tested?
  - What problems need to be overcome to apply LII in flows beyond laminar flames?
  - What do LII particle size measurements mean?

- Anna Ciajolo (Istituto de Ricerche sulla Combustione-CNR, Napoli, I):
  Spectroscopic and chemical analysis of aromatic structures in rich flames
  - Is the fluorescence emission of high molecular weight species sampled in rich flames related to the fluorescence measured in flames?
  - Which experimental constraints must be considered for the interpretation of fluorescence spectroscopic data in solution and in high-temperature gas phases?
  - Are LIF signals detected in rich flames due to PAH species? Is it possible to attribute fluorescence peaks to specific aromatic ring systems?

10.30 Group photo / coffee break

- Ulrich Boesl (TU München, D):
  Advanced laser mass spectrometry (REMPI-MS): Sensitive on-line trace analysis for combustion processes
  - Which chemical compounds are hard to detect (even with known laser diagnostic means) but are crucial for understanding combustion processes? Is there a stimulus for new or further development of introduced analytical techniques?
  - What are the processes of formation of large PAH in industrial incinerators?
  - Unwanted chemical reactions in catalytic converters that are used for reduction of pollutants emitted from combustion processes!

12.30-13.45 Lunch
(**)
17.00 Self-service coffee break

17.30-19.30 **Picosecond combustion diagnostics: applications of a new tool**
Discussion leader: Normand Laurendeau (U Purdue, West Lafayette, USA)

- Jim Gord (Wright Patterson Air Force Base, Dayton, USA):
  Applying high-repetition-rate, modelocked lasers to the study of combustion
  - What are advantages/disadvantages of high-repetition-rate vs. low-repetition-rate operation in ultrafast combustion studies?
  - Given that "quenching-insensitive" measurements are possible in real time, does it make sense to invest effort in the measurement of quenching rate constants?
  - Do ultrafast lasers hold any promise for the study of real-world (i.e., high-pressure) combustion, and what can be achieved in the transition from picosecond to femtosecond lasers?
- Andreas Brockhinke (U Bielefeld, D):
  The shorter the better? Problems and promises of picosecond LIF
  - Do psec lasers really lead to increased SNR for concentration / temperature measurements, or does the increased experimental overhead actually make matters worse?
  - Comparison of different strategies for quantitative radical concentration measurements (LIF, CRDS, non-linear techniques): Is there a "best way" to perform the measurements?
  - Photochemical effects in flames during the interaction with intense short pulses: Are these measurements still "non-intrusive"?

20.00-21.15 Dinner

21.30 Poster Session:
Development of linear and non-linear techniques, picosecond and infrared diagnostics

Tuesday, June 22, 1999

7.30-8.30 Breakfast
(*)

9.00-12.30 **Improving combustion chemistry: diagnostics in laminar flames**
Discussion leader: Kermit Smyth (National Institute of Standards and Technology, Gaithersburg, USA)

- Gregory Smith (Stanford Research Institute International, Menlo Park, USA):
  Do laser measurements tell us the right things about flame chemistry?
- Which diagnostic experiments can be well enough designed so that comparisons with models unambiguously tell us something about the chemistry?
- Can we find (semi-quantitative?) laser diagnostics for larger species to address the flame chemistry of more complex fuels?
- What specific flame chemistry issues are worthwhile to diagnose, and are we presently applying the right combinations of tool to obtain valid information?

10.00 Coffee break

- James Fleming (Naval Research Laboratory, Washington, USA):
  Fire suppression agent research
- How to develop chemical mechanisms for elements other than H, C, O, and N?
- How to validate these mechanisms with little or no kinetic data?
- What experimental data and techniques are most useful towards validation?
- Phillip Paul (Sandia Combustion Research Facility, Livermore, USA):
  PLIF imaging of native hydrocarbon radicals
- What is an appropriate interpretation of a PLIF image of a flame radical?
- Is there a way to get information on heat release or reaction rate?
- What spectroscopic/collisional data is needed to get to 'quantitiative' measurements and is this necessary or even possible?

12.30-13.45 Lunch
(**)
17.00 Self-service coffee break

17.30-19.30 **Active combustion control**
Discussion leader: Ronald Hanson (U Stanford, USA)

- Sébastien Candel (Ecole Centrale, Paris, F):
  The role of diagnostics in active control of combustion
- What should be measured for combustion control and active combustion control?
- Sensors applicability. How to install sensors on typical devices. What works and what does not.
- Are optical diagnostics applicable in real environments? Success and failure stories requested.
- The future of imaging in combustion control.

- Mark Allen (Physical Sciences Inc., Andover, USA):
  Spectroscopic sensors for combustion control in industrial and propulsion applications
  - How do we relate what we can measure to what is needed for control?
  - Insertion of new spectroscopic sensors into commerical/industrial markets is impeded by cost and lack of critical needs: How can we respond to this situation?
  - Device (laser/detector/fiber components/etc) availability is a critical element of new sensor development. Are we as a community sufficiently involved in this level of R&D so as to bridge present gaps between telecommunication developers and gas sensor users?

20.00-21.15 Dinner

21.30 Poster Session:
Turbulence, flow diagnostics

Wednesday, June 23, 1999

7.30-8.30 Breakfast

(*)

9.00-12.30 **Diagnostics in challenging combustion situations**

Discussion leader: Richard Miles (U Princeton, USA)

- Douglas Greenhalgh (U Cranfield, UK):
  Two-phase fuel imaging in practical combustion systems
  - Accurate calibration of practical measurements
  - LIF of evaporating sprays
  - Diagnostics for high-pressure dense sprays

10.00 Coffee break

- Thierry Baritaud (Institut Français du Pétrole, Rueil-Malmaison, F):
  Diagnostics of fuel and pollutants for automotive spray combustion
  - Which diagnostic techniques are useful for dense spray structure and characteristics studies?
  - Which diagnostics should be applied for auto-ignition diagnostics (radicals, ...) and temperature in industrial systems such as engines?
  - What is really needed to support engine development and engine CFD code development?
- Hans-Robert Volpp (U Heidelberg, Germany):
  Picosecond sum frequency generation for the investigation of catalytic combustion
  - Catalytic combustion: What can be learned from catalysis studies carried out under ultra-high vacuum conditions on well-defined single-crystal surfaces?
  - Validation of heterogeneous combustion modeling: Is probing the gas-phase enough?
  - SFG spectra simulation, interpretation and quantification: A possibility for quantitative *in situ* monitoring of bonding, location and reactivity of surface species?

12.30-13.45 Lunch

(**)

17.00 Self-service coffee break

17.30-19.30 **Diagnostics in turbulent combustion**

Discussion leader: James Driscoll (U Michigan, Ann Arbor, USA)

- Thierry Poinsot (Institut National Polytechnique and CERFACS, Toulouse, F):
  What do we need most in understanding turbulent combustion – more diagnostics, more theory, larger DNS?
- How sophisticated must chemistry description be in DNS to allow proper comparison with experimental data?
- How reliable are experimental data and what is the error margin (when experiments and DNS are compared) simply due to the fact that we do not have reliable chemical schemes?
- Does it make sense to try to compare radical measurements in experiments and DNS in turbulent flames? Or should we limit this kind of study to simpler flows such as flame vortex interactions? What do we really learn from this which is useful for turbulent combustion models? What have we really used from this in existing models?
- Gerd Grünefeld (U Bielefeld, D):
  Instantaneous velocity field measurements in unsteady laminar and turbulent flames without particle seeding
- 'Complete' single-shot characterization of turbulent combustion
- Diagnostics in DI gasoline engines
- 3D techniques

20.00-21.15 Dinner

21.30 Poster Session:
Harsh environment, engine diagnostics

Thursday, June 24, 1999

7.30-8.30 Breakfast

(*)

9.00-12.30 **New questions for combustion diagnostics**

Discussion leader: Jürgen Wolfrum (U Heidelberg, D)

- Kenneth Brezinsky (U Illinois, Chicago, USA):
  Opportunities for laser diagnostics in the combustion synthesis of materials
- Combustion synthesis of materials
- Laser diagnostics in hostile environments
- Multiphase combustion systems

10.00 Coffee break

- Catherine Koshland (U Berkeley, USA):
  Diagnostic requirements for toxic emission control
- Diagnostics to assess metal-hydrocarbon interactions, gas-phase and heterogeneous
- Particle health effects - importance of size and chemical composition
- Control of mixtures, and of persistent bioavailable air toxics such as dioxin
- Charles Kolb (Aerodyne, Billerica, USA):
  Combustion emissions and atmospheric chemistry
- Combustion exhaust emissions
- Atmospheric photochemistry and aerosol microphysics
- Atmospheric trace species budgets

12.30-13.45 Lunch

(**)

17.00 Self-service coffee break

17.30-19.30 **New approaches for combustion diagnostics**

Discussion leader: Mark Linne (Colorado School of Mines, Golden, USA)

- Clemens Kaminski (Lund Institute of Technology, S):
  Development and applications of an ultra high speed laser/detector system for combustion diagnostics
- How can time-resolved data be used to improve turbulence/chemistry models and practical engine design?
- 3 dimensional imaging of turbulent reactive flows.
- What experiments in this field would the Gordon community like to see in the future?
- Thomas Kulp (Sandia Combustion Research Facility, Livermore, USA):
  Light sources based on quasi-phasematched materials: Potential as new spectroscopic tools
- What are the possibilities and needs for new sources and tuning capabilities?
- What new performance attributes are made available by new PPLN structures?

20.00-21.15 Dinner

21.30 Poster Session:
Chemistry, soot and particle diagnostics

Friday, June 25, 1999

7.30-8.30 Breakfast
End of conference

(*)	The time after breakfast should be used to remove the posters of the previous session.
(**)	During the break in the afternoon the posters for the evening session can be put up. As from 17.00 the posters will be ready for preview with the poster presenters being present for first discussions (17.00-17.30 and 19.30-20.00).

PROGRAM OF POSTER SESSIONS

Poster Session 1 (Monday)

Development of linear and non-linear techniques, picosecond and infrared diagnostics

1 M. Schenk, T. Seeger, A. Leipertz
Temperature and simultaneous N_2/O_2-, N_2/CO_2- and $N_2/O_2/CO_2$-concentration measurements using dual broadband pure rotational CARS

2 K. M. Bultitude, P. M. Danehy
Characterisation of a modeless broadband coherent anti-Stokes Raman spectroscopy (BB-CARS) system

3 J. J. Ju, J.-s. Ryu, C. W. Park, D.-H. Yu, J.-H. Lee, J.-S. Chang, J. W. Hahn
Theory of forward degenerate four-wave mixing in two-level saturable absorbers and experiment of C_2 degenerate four-wave mixing

4 G. M. Lloyd, P. Ewart
Single-shot multiplex DFWM measurements of flame temperature and radical species concentration along a line

5 M. J. Fernée, P. F. Barker, H. Rubinsztein-Dunlop, A. E. W. Knight
Seeded parametric four-wave mixing for sensitive detection in combustion environments

6 J. Reppel, Z. T. Alwahabi, K. D. King, G. J. Nathan
Laser polarisation spectroscopy imaging of chemical species

7 G. R. Souza, K. M. Gordon, J. H. Miller
Applications of higher harmonics to wavelength modulation spectroscopy using tunable diode laser spectroscopy

8 J. Tobai, T. Dreier
Measurement of relaxation times of OH and NH in atmospheric pressure flames using picosecond pump-probe degenerate four-wave mixing

9 Brockhinke, W. Kreutner, U. Rahmann, T. Settersten, M. Linne, K. Kohse-Höinghaus
Polarization effects in time-resolved LIF spectra in atmospheric pressure flames

10 T. B. Settersten, M. A. Linne, G. J. Fiechtner, J. Gord, A. Brockhinke, A. Bülter
Development of picosecond pump/probe spectroscopy

11 J. Luque, D. R. Crosley
Radiative, collisional, and predissociative effects in CH quantitative laser-induced fluorescence

12 P. Jamette, P. Desgroux, B. Deschamps
Laser induced fluorescence detection of NO in the burnt gases of propane/air engine flames with A-X(0,1) excitation using a MOPO

13 J. Luque, D. R. Crosley
Transition probabilities and lifetimes in the A-X, D-X, and D-A systems of NO

14 W. Lee, R. Leiweke, M. J. Fernée, W. R. Lempert
LIF and Raman studies of vibrational energy transfer in CO laser-sustained non-equilibrium plasmas

15 R. L. Farrow, D. A. V. Kliner
Measurement of ground-state OH rotational energy-transfer rates using picosecond lasers

16 M. Schütte, G. Grünefeld, A. Maxein, P. Andresen
Simultaneous multiple-line Raman/Rayleigh/LIF measurements in combustion as a way to 3D spatial resolution

17 L. Dabringhausen, A. Kurtz
Differential interferometry for temperature measurements in flames

18 D. Nassif-Pugsley, L. Hüwel
Temporally and spatially resolved Rayleigh scattering investigations of laser-induced plasmas as a function of pressure

19 R. B. Miles, A. Yalin, Z. Tang
High resolution and high throughput resonant dispersion filter for rotational Raman imaging

20 B. J. Kirby, R. K. Hanson
Infrared PLIF imaging of CO and CO_2

21 M. Feng, F. Gouldin
IR absorption tomography of merging multiple jets

22 P. Powers, P. Yaney
Application of a tunable pulsed IR source using a PPLN OPG-OPA system to combustion diagnostics

23 M. Allen, E. Wetjen, D. Sonnenfroh, C. Gmachl, F. Capasso
Combustion sensors based on room-temperature mid-IR lasers

24 Ritchie, B. Scully, J. M. Seitzman
Optical diagnostics and sensors for active control of combustion

25 H. Pitz, T. Fernholz, C. Giesemann, V. Ebert
NIR-diode-laser-based in-situ-gas analysis for the monitoring of ignition processes in gasfired powerplants

26 P. L. Varghese, J. J. Mach, J. J. Jagodzinski
Modulated filtered Rayleigh scattering measurements of velocity using near-IR diode lasers

Poster Session 2 (Tuesday)
Turbulence, flow diagnostics

1 J. A. Wehrmeyer, L. A. Ribarov, D. A. Oguss, F. Batliwala, R. W. Pitz, P. A. DeBarber
Flow tagging velocimetry for low and high temperature flowfields

2 S. Schlamp, E. B. Cummings, H. G. Hornung
Beam misalignments and fluid velocities in LITA (Laser-Induced Thermal Acoustics)

3 B. Hemmerling, D. N. Kozlov, A. Stampanoni-Panariello
Measurement of gas flow velocities by electrostrictive laser-induced gratings

4 G. S. Diskin
Use of RELIEF velocimetry to study compressible jet mixing

5 S. Doose, C. Orlemann, C. Schulz, J. Wolfrum
Highly resolved investigation of turbulent channel flow: Temperature distribution and NO flow tagging measurements

6 P. Barker, J. Grinstead, R. Miles
Temperature measurement in unseeded supersonic air flows by predissociated laser-induced thermal gratings

7 A. Bresson, F. Grisch
Instantaneous and quantitative imaging of turbulent flows. Two solutions based on acetone fluorescence

8 D. Knaus, F. Gouldin
Developments in cross-plane imaging

9 D. G. Fletcher
Arc-plasma device characterization using LIF of atomic species

10 P. M. Danehy, P. Mere, S. O'Byrne, M. Cooper, M. J. Gaston, P. C. Palma, A. F. P. Houwing
PLIF velocimetry in a free-piston shock tunnel

11 J. S. Fox, P. M. Danehy, M. J. Gaston, A. F. P. Houwing
Fuel mole-fraction imaging for mixing studies in a shock tunnel

12 R. J. Cattolica
Laser fluorescence measurement of shock wave location in combustion driven free jets

13 P. C. Palma, S. G. Mallinson, S. O'Byrne, P. M. Danehy
Planar-laser induced fluorescence thermometry in a hypersonic boundary layer flow

14 M. Beyer, D. Markus, M. Spilling
Application of laser diagnostics to reactive jets emerging from flameproof joints

14 F. Grisch, B. Attal-Trétout, P. Bouchardy, Y. Biscos, G. Lavergne, V. R. Katta, M. Roquemore, Instantaneous sampling of temperature and concentrations in periodic flames

15 A. Brockhinke, A. Bülter, J. C. Rolon, K. Kohse-Höinghaus
Ps-LIF measurements of minor species concentration in a counterflow diffusion flame interacting with a vortex

16 P.-H. Renard, G. J. Fiechtner, J. R. Gord, C. D. Carter, K. D. Grinstead, Jr., J. C. Rolon, D. Thévenin
Interaction of a single vortex ring with a opposed-jet diffusion flame

17 J. F. Driscoll, J. O. Sinibaldi, J. M. Donbar, C. D. Carter
Vorticity and strain fields of a premixed flame-vortex interaction, imaged using PIV-OH and OH-CH diagnostics

18 A. M. Schaffer, R. K. Mohammed, M. B. Long, M. D. Smooke
Measurement of species and temperature using difference Raman scattering

19 M. W. Renfro, G. B. King, N. M. Laurendeau
Time-series measurements of CH and NO in turbulent nonpremixed flames

20 T. Plessing, M. S. Mansour, R. K. Cheng, N. Peters
Laser optical investigation of the structure of isotropic turbulent premixed methane-air flames

21 W. Meier, O. Keck, V. Jörres, W. Stricker
Spontaneous Raman scattering and 2D LIF in confined swirling natural gas flames: Temperature, species concentrations, and structures

22 S. Linow, E. P. Hassel, J. Janicka
Raman/Rayleigh measurement of concentration and temperature in pure oxygen/hydrogen flames: Assessment of data reduction schemes

23 J. H. Frank, R. S. Barlow
Comparison of CO measurements by Raman scattering and two-photon LIF in laminar and turbulent methane flames

24 K. T. Walsh, J. Fielding, M. B. Long, M. D. Smooke
Two-dimensional laser diagnostics of coflow laminar diffusion flames in a microgravity environment

25 A. Ratner, J. M. Donbar, C. D. Carter, J. F. Driscoll, W. J. A. Dahm
The regime of "intensely wrinkled" nonpremixed turbulent flames - images of the CH-OH reaction zones and velocity fields

Poster Session 3 (Wednesday)

Harsh environment, engine diagnostics

1 D. Zeh, D. Brüggemann
Combined application of spontaneous Raman and Mie scattering to fuel sprays

2 B. Mewes, D. Brüggemann
Quantitative spray diagnostics with hydrogen bonding sensitive Raman spectroscopy

3 J. Posner, D. Dunn-Rankin, N. Brock, M. Brown, P. DeBarber
Using resonant holographic interferometry as a multi-phase combustion diagnostic

4 C. Mounaïm-Rousselle
Droplet sizing by Mie scattering interferometry in engines

5 M. C. Jermy, N. Farrugia, P. LeGal, D. A. Greenhalgh
Two dimensional drop size measurements in real sprays

6 M. S. Brown, Y. Li, W. L. Roberts
Transient grating thermometry in high pressure flames

7 P.-E. Bengtsson, J. Bood, C. Brackmann
Rotational coherent anti-Stokes Raman spectroscopy for measurements of temperature and oxygen concentration in practical combustion applications

8 Ö. Andersson, B. Axelsson, P-E. Bengtsson, J. Bood, R. Collin, C. Löfström, H. Neij, M. Richter, M. Aldén
Developments of laser diagnostic techniques for combustion diagnostics in practical environments

9 H. Finke, S. Krüger, J. Bartelheimer, G. Grünefeld
Measuring the relative velocity field of gas and liquid phase in sprays and aerosols

10 R. Bratfalean, A. J. Grant, G. M. Lloyd, P. Ewart
Theory of practical DFWM and applications to combustion systems

11 J. Engström, C. Kaminski, J. Nygren, M. Aldén
Two-dimensional temperature measurements of flames using two-line atomic fluorescence with indium

12 F. Hildebrand, C. Schulz, J. Wolfrum, E. Wagner
NO-LIF diagnostics in a Diesel engine using KrF excimer laser excitation

13 A. Dreizler, R. Schiessl, P. Pixner, U. Maas
Absolute measurement of formaldehyde and OH radicals in IC engines using calibrated laser induced fluorescence

14 N. Dam, E.-J. van den Boom, G. Stoffels, C. Spaanjaars, P. Monkhouse, J. J. ter Meulen
Diagnostics of combustion in realistic Diesel engines - to LIF or not to LIF?

15 G. Ortolan, B. Deschamps
Visualization of vapour and liquid phases in gasoline direct injection engines with planar laser-induced exciplex fluorescence

16 O. Angrill, H. Geitlinger, Th. Streibel, R. Suntz, H. Bockhorn
Influence of simulated exhaust gas recirculation on soot formation in diffusion flames

17 J. D. Black
Laser induced incandescence measurement of particles in aero-engine exhausts

18 U. Boesl, H. Nagel, P. Püffel
Dynamic trace analysis by means of laser mass spectrometry: Exhaust emissions from combustion engines

19 R. J. Locke, R. C. Anderson, Y. R. Hicks, M. M. Zaller, Y. Gu, G. P. Reck, E. W. Rothe
1-D, 248nm vibrational-Raman species measurements from an advanced high-pressure, jet-A fueled, turbine-engine combustor test facility

20 C. S. Cooper, N. M. Laurendeau
Laser-induced fluorescence measurements of nitric oxide in high-pressure lean direct-injection spray flames simulating gas turbine operation

21 M. Allen, J. Frank, M. Miller, C. Gittins
PLIF and Raman diagnostics in a gas turbine combustor operating up to 20 atm

22 D. Wolff-Gaßmann, U. E. Meier, J. Heinze, M. Frodermann, I. Magnusson, G. Josefsson
Application of two-line OH thermometry in technical combustion systems at elevated pressure

23 N. Docquier, F. Lacas, S. Candel
Control of gas turbine combustion

24 S. Yeralan, P. A. DeBarber, M. S. Brown, J. A. Wehrmeyer, R. W. Pitz
Use of rotational and rotational-vibrational Raman spectroscopy for rocket combustion measurements

25 W. Clauss, V. I. Fabelinsky, D. N. Kozlov, V. V. Smirnov, O. M. Stel'makh, K. A. Vereschagin
Single-shot CARS-thermometry based on H_2 and H_2O spectra in a cryogenic hydrogen/oxygen combustion chamber

Poster Session 4 (Thursday)

Chemistry, soot and particle diagnostics

1 I. Derzy, S. Cheskis, V. A. Lozovsky
Absorption spectroscopy of low pressure flat flames; problems, methods and prospects

2 D. I. Shin, G. Peiter, T. Dreier, H. R. Volpp, J. Wolfrum, S. Hasko
Quantitative detection of radicals and intermediate species in atmospheric pressure slot burners relevant to NO_x chemistry

3 B. Atakan, A.T. Hartlieb, A. Lamprecht, K. Kohse-Höinghaus
Laser diagnostics in near sooting low-pressure flames

4 R. Klein-Douwel, J. B. Jeffries, G. P. Smith, J. Luque, D. R. Crosley
Comparison of non-predissociated and predisssociated LIF of CH in an atmospheric pressure partially premixed flame

5 C. Moreau, E. Therssen, P. Desgroux, L. R. Sochet, A. Chapput, M. Barj
Laser-induced fluorescence of CH in laminar diffusion flames of methane: Application to sooting flames

6 V. A. Lozovsky, I. Derzy, S. Cheskis
Absolute concentration profiles of NH and NH_2 radicals measured by cavity ring down spectroscopy and intra cavity laser absorption spectroscopy in low pressure methane flat flame doped with N_2O

7 R. Evertsen, R. L. Stolk, J. J. ter Meulen
Cavity ring down spectroscopy on CH and OH in atmospheric flames

8 M. J. Fernée, W. R. Lempert
CW cavity ringdown absorption spectroscopy for trace species detection

9 S. Spuler, A. Sappey, S. Snyder, M. Linne
Cavity ringdown laser absorption spectroscopy applied to urban air toxics

10 T. G. Owano, C. H. Kruger
Cavity ringdown spectroscopy of hydrocarbons

11 X. Mercier, P. Desgroux
Species concentration monitoring in flames by cavity ring-down spectroscopy: A study of the spatial resolution and of the detection limit in hostile environments

12 F. Ossler, T. Metz, M. Aldén
Picosecond laser-induced fluorescence from gas-phase polycyclic aromatic hydrocarbons at elevated temperatures: Implications to combustion diagnostics

13 P. Minutolo, L. A. Sgro, A. D'Alessio
Spectroscopic characterization of nanometer sized carbonaceous particulate matter in the inception region of lightly sooting flames and in non-sooting flames

14 R. T. Wainner, J. M. Seitzman
LII soot measurements: Quantitative considerations

15 S. Schraml, S. Dankers, S. Will, A. Leipertz
On-line characterization of soot and nano-particles by laser-induced incandescence (LII)

16 D. R. Snelling, K. A. Thomson, G. J. Smallwood, Ö. L. Gülder
Improved soot volume fraction measurement with two-dimensional imaging in laminar diffusion flames

17 B. Hemmerling, A. Stampanoni-Panariello
Investigation of soot by two-color four-wave mixing

18 R. L. Vander Wal, T. M. Ticich, J. R. West Jr.
Laser-induced incandescence applied to metal nanoparticles

19 D. Nassif-Pugsley, T. Berg
Laser induced fluorescence studies of SiO vapor as a function of temperature heating a quartz tube in a methane burner

20 H. Zhang, F.-Y. Yueh, J. P. Singh
Performance evaluation of laser induced breakdown spectrometry as a multi-metal continuous emission monitor

21 U. Gottwald, P. Monkhouse, N. Wulgaris
In-situ determination of alkali and heavy metal species in flue gas of fluidised bed combustors by excimer laser induced fragmentation fluorescence

22 H. Oser, M. J. Coggiola, G. W. Faris, D. R. Crosley
Development of a real-time jet REMPI monitor for dioxins

23 C. B. Dreyer, J. W. Daily, A. Abbud-Madrid, M. C. Branch
Spectroscopic study of the $B^1\Sigma^+$-$X^1\Sigma^+$ and $B^1\Sigma^+$-$A^1\Pi$ transitions of magnesium oxide and PLIF of MgO above burning magnesium

24 J. W. Hahn, Y. S. Yoo, J. Y. Lee, J. W. Kim, H.-W. Lee
A new spectrometer design of cavity ring-down spectroscopy with a cw laser

25 J. Fielding, M. B. Long
Comparison of intensified and non-intensified Rayleigh scattering measurements for scalar dissipation determination